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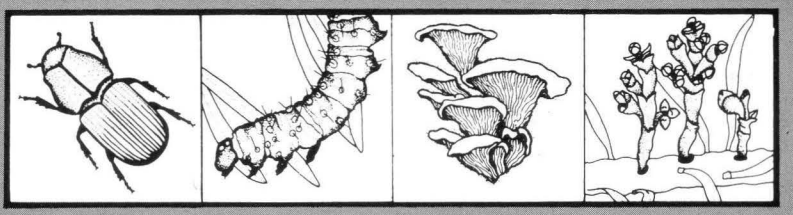

Report 93-5

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PERMANENT PLOTS FOR STUDYING THE SPREAD AND INTENSIFICATION OF LARCH DWARF MISTLETOE AND THE EFFECTS OF THE PARASITE ON GROWTH OF INFECTED WESTERN LARCH ON THE FLATHEAD INDIAN RESERVATION, MONTANA.

by

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INTRODUCTION

Western larch dwarf mistletoe (*Arceuthobium laricis* (Piper) St. John) is a wide-spread forest disease agent that occurs throughout the range of western larch (*Larix occidentalis* Nutt.) in the northwestern United States. Dwarf mistletoes are parasitic plants that depend on their conifer hosts for water and nutrients, causing reduced vigor, decreased diameter and height growth, reduction in cone and seed crops, and mortality.

Information that quantifies the spread and intensification of dwarf mistletoes and their effects on tree growth and mortality is necessary for formulating disease management strategies. Some information is available for other dwarf mistletoe species, particularly, lodgepole pine dwarf mistletoe (*A. americanum*) (Hawksworth and Johnson 1989). However, very little data is available for western larch dwarf mistletoe (WLDM). Most of the current information is based on data from unmanaged stands, or stands managed under even-aged systems.

Traditionally, silvicultural management of dwarf mistletoe has been based on even-aged management because control of dwarf mistletoe is best achieved through the removal of infected stands and replacement with mistletoe-free regeneration (e.g., clear cuts, and seed tree and shelterwood cuts in which the residual overstory is promptly removed following stand regeneration) (Hawksworth and Johnson 1989). However, with the current pressures to limit clear cutting and to leave residuals on a site until visual recovery has been achieved, forest managers are starting to explore alternative treatments of dwarf-mistletoe-infected stands. As a result, many questions are being raised about the impacts of dwarf mistletoe on the productivity of stands managed under uneven-aged systems. Unfortunately, there is not much data available at this time to answer most of these questions.

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Growth and yield simulation models like Prognosis (Stage 1973, Wykoff et al. 1982) are tools that allow managers to project the future productivity of forest stands under a variety of management treatments. Pest impact models linked to the growth and yield simulation models allow for the incorporation of disease and insect effects into these productivity projections. In recent years, a dwarf mistletoe impact model has been developed which links directly to Prognosis (Hawksworth et al. 1992. Work is currently underway within the UDSA Forest Service to develop a new and better Prognosis-linked dwarf mistletoe model. Several areas of concern have been identified during work with both the existing and the up-coming model: (1) there are very few data sets available for building the models; (2) data for building dwarf mistletoe-related mortality functions is very limited; (3) existing data sets do not adequately cover all dwarf mistletoe host species of concern; and (4) existing data sets are limiting in their geographic representation. Permanent plots can supply data for the development, validation, and calibration of dwarf mistletoe impact models.

This study has four main objectives: (1) to quantify the spread and intensification of dwarf mistletoe in western larch with and without overstory removal and precommercial thinning, (2) to quantify the growth effects due to dwarf mistletoe in infected western larch with and without overstory removal and precommercial thinning, (3) to provide a visual demonstration of the treatment effects on stand growth and development, and (4) to provide data for the validation of dwarf mistletoe models for stand conditions similar to those found in this study.

METHODS

Study Area. The study is located in a management unit in the North Valley Creek Area, on the southern end of the Flathead Indian Reservation (IR), Montana. The unit was selectively harvested in 1972; site preparation encouraged prolific natural regeneration. The existing stand is a mature, predominantly western larch overstory with a heavily stocked understory of western larch saplings and scattered Douglas-fir, sub-alpine fir, lodgepole pine, ponderosa pine, Engelmann spruce, and western redcedar. Overstory trees are heavily infected with larch dwarf mistletoe with most trees exhibiting extensive brooming. Understory trees also show evidence of extensive dwarf mistletoe infection.

Sample Design and Treatments. This is a split plot design with four replications of two plots, each receiving one of two overstory treatments (overstory removal, no overstory removal). Each plot was divided into two 1/4-acre square subplots, each receiving one of two thinning treatments (12- x 12-foot spacing, no thinning). The subplots to be thinned were selected by the flip of a coin. Each subplot was surrounded by a 33-foot-wide buffer which received the same treatment as the subplot. Subplots that were neither logged nor thinned will be used as controls.

Plot Establishment. The plot establishment and silvicultural treatments were carried out in June to September, 1991. Plot boundaries were established prior to treatment. Plots scheduled to receive overstory removal were established at least 150 feet away from residual overstory trees.

Boundaries of each square subplot were measured with a staff compass and measuring tape. Corners were located by measuring diagonals at 73.8 feet from an initial plot center. The boundaries were also measured to provide a check for errors (each side = 104.36 feet). The corners were monumented with metal posts. Plot and sub-plot numbers and corner bearings were written on a metal tag attached to each post (e.g., Plot 1, Subplot 2, SE Corner). The corners of the buffer zone were also marked with metal stakes.

A map of the plot layout is shown in Figure 1. Plots labeled with a "1" (i.e., II1) received an overstory removal treatment (logged) and plots labeled with a "2" (i.e., II2) did not receive an overstory treatment (un-logged). Subplots labeled with an "a" (i.e., II1a) were thinned to a 12- x 12-foot spacing and subplots labeled with a "b" (i.e., II1b) were not thinned.

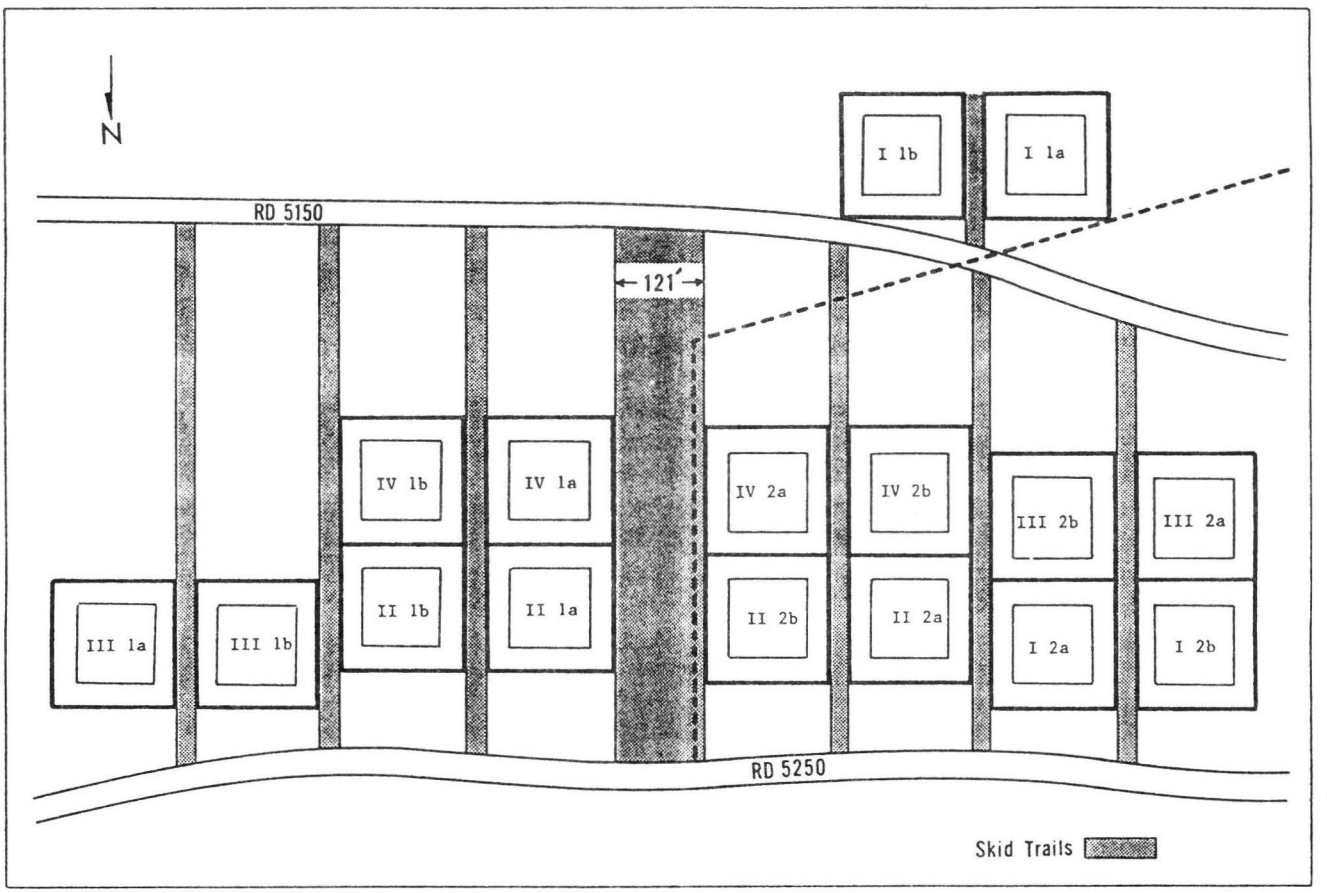

Figure 1--Map of plot layout: I-IV = replication number; 1 = overstory removal, 2 = no overstory removal; a = thinned to a 12- x 12-foot spacing; b = no thinning. The heavy dotted line indicates the approximate boundary between the part of the stand where overstory removal was performed (to the left) and the part of the stand not logged (to the right).

Pre-Treatment Surveys. All subplots scheduled to receive overstory removal and/or thinning were surveyed prior to treatment to record pre-treatment stocking and dwarf mistletoe levels. All overstory trees on the subplots and surrounding buffer zones were evaluated for tree species, tree height, diameter at breast height (d.b.h.), and dwarf mistletoe rating (DMR) (Hawksworth 1977). The understory trees were sampled using five one-hundredth-acre circular plots per subplot (one at 36.8 feet from each corner and one at subplot center). Understory trees, 4.5 feet or taller, were counted and evaluated for tree species and DMR.

Each subplot was evaluated for percent slope, aspect, and habitat type (Pfister et al. 1977). Age was taken on two western larch overstory trees per subplot for estimating site index.

Crop Tree Selection. Desired crop trees were flagged on all subplots on a 12- x 12-foot spacing. Crop trees were marked on the unthinned plots as well because these are the trees to be tagged. They will represent a comparable data set to the trees on the thinned plots for future growth comparisons. The following criteria were used for assigning crop tree selection.

1. Trees not infected with dwarf mistletoe, with good form and vigor, and free from other pests and defects.

2. Trees with infections in less than half the branches in the lower one-third of the crown (DMR < (2)

3. Trees with infections in less than half the branches in the lower two-thirds of the crown (DMR < (3).

Post-Treatment Data Collection. Pre-numbered metal tags were attached to trees identified as crop trees on all subplots (residual trees on the thinned subplots and flagged trees on the unthinned subplots). On trees 2 inches in diameter and larger, the tags were nailed to the main stem 4.5 feet above the ground. On trees of smaller diameter, the tag was wired loosely on the main stem at the branch whorl closest to 4.5 feet, and a red paint spot was applied to the main stem at 4.5 feet. When plots are remeasured, the wired-on tags will be nailed at 4.5 feet when the trees reach 2 inches in diameter. The following data items were recorded for every tagged tree: tree number, species, d.b.h., tree height, height to bottom of live crown (later used to compute live crown ratio), DMR by thirds of crown, crown class, tree status, and the three most damaging agents on the tree (in addition to dwarf mistletoe).

On the unthinned subplots, additional sampling was done using five one-hundredth-acre circular plots (one at 36.8 feet from each corner post and one at subplot center). The center of each circular plot was permanently marked with an orange fiberglass stake to assure that sampling will be done from the same point during future plot remeasurements. Trees within the circular plots were not tagged, but all trees 4.5-feet tall and greater were evaluated for all of the same data items recorded for the tagged trees. This additional data provides better information on total subplot volume and dwarf mistletoe infection levels.

On the unlogged subplots and surrounding buffers, overstory trees were tagged and evaluated for the same data items as the understory trees. This data will be used, primarily, to track the mortality of the overstory trees.

Collection procedures and codes for all of the above data items were consistent with the R-1 Timber Management Handbook (USDA Forest Service 1989). Initial plot remeasurement will be at 3 years following establishment to account for latent infections. Subsequent remeasurements will be at 5-year intervals.

DATA ANALYSIS

All subplots were representative of the *Abies lasiocarpa/Clintonia uniflora* habitat type. Fourteen were representative of the *Menziesia ferruginea* phase. One was representative of the *Xerophyllum tenax* phase, and one was representative of the *Aralia nudicaulis* phase. Subplot slopes ranged from 17 to 46 percent with generally northern aspects (NNW, N, and NNE).

A total of 4,027 understory trees of all species were sampled, including tagged crop trees and trees on one-hundredth-acre sample plots. Of this total, 1,694 (42 percent) were infected. The average DMR ($\overline{DMR}$) of all sampled understory trees was .58 and the average DMR of the infected trees ($\overline{DMI}$) was 1.39. Three thousand four hundred seventy-five (85 percent) of all sampled understory trees were western larch; 49 percent of the larch were infected. The $\overline{DMR}$ of all larch understory trees was .67.

The characteristics of understory trees on each subplot are summarized in Table 1. This information was calculated from data taken for understory trees on one-hundredth-acre sample plots. Data for trees on thinned subplots were taken prior to treatment. Subplot stocking was quite variable, ranging from 680 to 8,280 trees per acre with a mean of 3,488 trees per acre (sd=1,991). The percent of trees infected on each subplot was also variable, ranging from 1.3 to 69.1 percent with a mean of 40 percent (sd=20.56). Western larch was a large component of all plots, ranging from 44 to 99 percent with a mean of 85 percent (sd=16.21).

A total of 1,237 understory trees were tagged as comparable crop trees and 693 (56 percent) of this total were infected. The $\overline{DMR}$ of all crop trees was .80 and the $\overline{DMI}$ was 1.34. Nine hundred eighty-four (80 percent) of the crop trees were western larch and 70 percent of the larch were infected. The $\overline{DMR}$ of the larch crop trees was .94.

The characteristics for designated crop trees on each subplot are summarized in Table 2. The percent total crop trees infected ranged from 4 to 80 percent with a mean of 58 percent (sd=20.07) and the percent larch infected ranged from 4 to 92 percent with a mean of 73 percent (sd=23.78). Subplot $\overline{DMR}$ ranged from .04 to 1.25 with a mean of .80 (sd=.31). Subplot $\overline{DMI}$ ranged from 1.00 to 1.58 with a mean of 1.34 (sd=.16).

Infection data for crop trees were broken down by the number of trees in each DMR class and by the number of trees with infections in each crown-third (lower, middle, upper) (Table 3). All trees but one had a DMR of 3 or less, and 69 percent of all infected trees had a DMR of 1. Ninety-eight percent of infected trees had infections in the lower crown third while only 0.3 percent had infections in the upper crown third.

The data presented in Tables 1, 2, and 3 show that the incidence of dwarf mistletoe infection in the understory trees was quite high even though the understory trees are less than 20 years old. However, the severity of infection in individual understory trees throughout the stand was low.

The height of infected crop trees ranged from 2.5 to 31.8 feet with a mean of 13.1 feet (sd=5.7) and the height of non-infected, understory trees ranged from 1.3 to 29.0 feet with a mean of 8.7 feet (sd=5.0). The d.b.h. of infected crop trees ranged from 0.1 to 4.2 inches with a mean of 1.2 inches (sd=0.7) and the d.b.h. of non-infected crop trees ranged from 0.1 to 3.1 inches with a mean of 0.8 inches (sd=0.6). Mean heights and d.b.h.'s were computed for infected and non-infected crop trees on each of the 16 subplots (Table 4). Students t-tests (Schefler 1980) were used to test the difference between the means for the height of infected trees versus the height of non-infected trees and for the d.b.h. of infected trees versus the d.b.h. of non-infected trees. Results showed that infected trees were significantly taller and bigger in diameter than non-infected trees. These results indicate that dwarf mistletoe infection is not yet causing any growth effects in these understory trees and suggest that the bigger the tree, the greater its probability of becoming infected because it poses a larger target for the reception of dwarf mistletoe seeds.

Table 1.--Number of trees per acre (TPA), number of infected trees per acre (INF TPA), percent infected (% INF), average dwarf mistletoe rating (DMR), average dwarf mistletoe rating of infected trees (DMI), number of western larch trees per acre (WL TPA), percent species composition of western larch (% WL), and percent western larch infected (% WL INF) for all understory trees on each subplot grouped by treatment.

	TPA	INF TPA	% INF	DMR	DMI	WL TPA	% WL	% WL INF
Logged, Thinned*								
I 1a	2,920	420	14.4	0.18	1.24	1,980	67.8	21.2
II 1a	3,680	2,220	60.3	1.03	1.71	3,460	94.0	62.4
III 1a	1,720	880	51.2	0.78	1.52	1,640	95.3	53.7
IV 1a	3,040	2,100	69.1	0.97	1.41	3,000	98.7	70.0
$\bar{x}$	2,840	1,405	48.8	0.74	1.47	2,520	89.0	51.8
Logged, Unthinned								
I 1b	2,020	1,160	57.4	0.68	1.19	1,640	81.2	70.7
II 1b	3,040	1,220	40.1	0.51	1.26	3.000	98.7	40.7
III 1b	2,740	320	11.7	0.12	1.00	2,360	86.1	13.6
IV 1b	2,000	980	69.1	0.97	1.41	1,920	96.0	51.0
$\bar{x}$	2,450	920	44.6	0.57	1.22	2,230	90.5	44.0
Unlogged, Thinned*								
I 2a	5,000	2,480	49.6	0.74	1.49	4,620	92.4	53.7
II 2a	3,080	1,360	44.2	0.60	1.37	2,720	88.3	50.0
III 2a	2,000	460	23.0	0.40	1.74	1,000	50.0	46.0
IV 2a	8,280	1,800	21.7	0.24	1.10	7,940	95.9	22.6
$\bar{x}$	4,590	1,525	34.6	.50	1.43	4,070	81.7	43.1
Unlogged, Unthinned								
I 2b	680	200	29.0	0.41	1.40	300	44.1	66.7
II 2b	7,500	100	1.3	0.01	1.00	6,840	91.2	1.5
III 2b	2,960	1,700	57.4	0.82	1.44	2,560	86.5	66.4
IV 2b	5,140	2,620	51.0	0.75	1.47	4,840	94.2	54.1
$\bar{x}$	4,070	1,155	34.7	.50	1.33	3,635	79.0	47.2
Total mean	3,488	1,251	40.7	0.58	1.36	3,114	85.0	46.5

* Data was taken prior to treatments

Table 2.--Number of trees, number of western larch (# WL), percent composition of western larch (% WL), number infected (# INF), percent infected (% INF), percent western larch infected (% WL INF), average dwarf mistletoe rating (DMR), average dwarf mistletoe rating of infected trees (DMI), average height (HGHT), and average diameter at breast height (DBH) for understory crop trees on each subplot, grouped by treatment.

	# Trees	# WL	% WL	# INF	% INF	% WL INF	$\overline{DMR}$	$\overline{DMI}$	HGHT (ft)	DBH (in)
Logged, Thinned										
I 1a	98	70	71.4	48	49.0	68.6	0.64	1.31	11.1	1.1
II 1a	95	85	89.5	73	76.8	85.9	1.11	1.44	11.2	1.1
III 1a	82	62	75.6	49	59.8	79.0	0.70	1.16	11.8	1.2
IV 1a	77	65	84.4	51	66.2	78.5	0.83	1.26	7.0	0.6
$\bar{x}$	88	71	80.2	55	62.3	78.0	0.82	1.29	10.3	1.0
Logged, Unthinned										
I 1b	85	65	76.5	52	61.2	80.0	0.88	1.44	8.2	0.7
II 1b	66	62	93.9	53	80.3	85.5	1.09	1.36	17.7	1.8
III 1b	95	80	84.2	25	26.3	31.3	0.27	1.04	10.7	1.1
IV 1b	76	57	75.0	46	60.5	80.7	0.83	1.37	9.2	0.7
$\bar{x}$	81	66	82.4	44	57.1	69.4	0.77	1.30	11.5	1.1
Unlogged, Thinned										
I 2a	68	59	86.8	54	79.4	91.5	1.25	1.57	13.9	1.3
II 2a	59	41	69.5	35	59.9	85.4	0.83	1.40	10.7	1.1
III 2a	69	47	68.1	36	52.2	76.6	0.71	1.36	12.7	1.2
IV 2a	83	75	90.4	41	49.4	54.7	0.60	1.22	11.5	0.9
$\bar{x}$	70	56	78.7	42	60.2	77.1	0.85	1.39	12.2	1.1
Unlogged, Unthinned										
I 2b	48	43	89.6	38	79.2	88.4	1.17	1.47	16.2	1.9
II 2b	83	70	84.3	3	3.6	4.3	0.04	1.00	14.3	1.2
III 2b	80	53	66.3	43	53.8	81.1	0.85	1.58	7.9	0.7
IV 2b	73	50	68.4	46	63.0	92.0	0.93	1.48	9.3	0.8
$\bar{x}$	71	54	77.2	33	49.9	66.5	0.75	1.38	11.9	1.2
Totals	1,237	984		693						
Total mean	77	61.5	79.6	43	57.5	72.7	0.80	1.34	11.46	1.09

Table 3.--The number of understory crop trees in each dwarf mistletoe rating (DMR) class, and the number of understory crop trees with dwarf mistletoe infections in each crown-third for each subplot, grouped by treatment.

	# of Tagged Crop Trees by DMR							# of Tagged Crop Trees with Dwarf Mistletoe Infections by Crown-Thirds		
	0	1	2	3	4	5	6	Lower	Middle	Upper
Logged, Thinned										
I 1a	50	36	9	3	0	0	0	47	8	0
II 1a	22	45	24	4	0	0	0	73	27	0
III 1a	33	41	8	0	0	0	0	46	11	0
IV 1a	26	40	9	2	0	0	0	51	9	0
Subtotal	131	162	50	9	0	0	0	217	55	0
Logged, Unthinned										
I 1b	33	34	13	5	0	0	0	50	16	0
II 1b	13	35	17	1	0	0	0	52	18	0
III 1b	70	24	1	0	0	0	0	25	1	0
IV 1b	30	32	12	1	1	0	0	46	12	2
Subtotal	146	125	43	7	1	0	0	173	47	2
Unlogged, Thinned										
I 2a	14	30	17	7	0	0	0	54	21	0
II 2a	24	25	6	4	0	0	0	35	9	0
III 2a	33	25	9	2	0	0	0	36	9	0
IV 2a	42	33	7	1	0	0	0	40	6	0
Subtotal	113	113	39	14	0	0	0	165	45	0
Unlogged, Unthinned										
I 2b	10	23	12	3	0	0	0	38	12	0
II 2b	80	3	0	0	0	0	0	2	1	0
III 2b	37	24	13	6	0	0	0	41	20	0
IV 2b	27	29	12	5	0	0	0	44	18	0
Subtotal	154	79	37	14	0	0	0	125	51	0
Grand total	544	479	169	44	1	0	0	680	198	2
% of total number of infected crop trees	--	69	24	6	0.1	--	--	98	29	0.3

Table 4.--Average height (HGHT) and average diameter at breast height (DBH) for dwarf mistletoe-infected and non-infected understory crop trees for each subplot, grouped by treatment.

	Infected		Non-infected	
	HGHT	DBH	HGHT (ft)	DBH (in)
Logged, Thinned				
I 1a	12.6	1.2	9.8	0.9
II 1a	12.8	1.2	5.9	0.5
III 1a	8.6	0.7	4.6	0.4
IV 1a	14.0	1.3	7.6	0.7
Logged, Unthinned				
I 1b	9.5	0.9	6.1	0.4
II 1b	18.7	1.9	13.5	1.2
III 1b	11.6	0.9	8.3	0.7
IV 1b	12.6	1.2	7.7	0.8
Unlogged, Thinned				
I 2a	14.8	1.3	10.3	1.1
II 2a	15.6	1.4	8.6	0.8
III 2a	14.3	1.4	6.7	0.6
IV 2a	14.0	1.2	9.0	0.7
Unlogged, Unthinned				
I 2b	17.6	2.1	11.0	1.2
II 2b	20.7	1.8	14.0	1.2
III 2b	10.0	0.8	5.4	0.6
IV 2b	10.7	0.9	7.0	0.7

Because we will eventually want to analyze the effects of the treatments (overstory removal and thinning) on dwarf mistletoe spread and intensification (measured by the variables $\overline{DMR}$, $\overline{DMI}$, # of trees infected, percent total infected, and percent larch infected) and on tree growth (measured by the variables of height and d.b.h.) it was important to test the intial difference between the means of the variables for the four treatment groups. Analysis of variance tests were performed using the SYSTAT statistical package (Wilkinson 1989). None of the variable means tested were significantly different between any of the treatment groups ($p=.20$). Therefore, there are no existing differences between treatment groups for the before-mentioned variables for which to account in future statistical analyses of treatment effects.

Data for overstory trees of all species on each subplot are summarized in Table 5. Data for overstory trees on subplots that received an overstory removal treatment were gathered prior to treatment. The number of trees per subplot was quite variable, ranging from 1 to 18 with a mean of 7.8 (sd=4.37). Subplot age ranged from 152 to 196 with a mean of 183 (sd=14). Site indices were not calculated because all the dominant western larch overstory trees were moderately to heavily infected with dwarf mistletoe and, therefore, would not give an accurate estimate of site quality.

A summary of the data for western larch overstory trees on each subplot and its surrounding buffer is presented in Table 6. Trees in the buffer zone were taken into consideration because they are close enough to the subplot to have a potential impact on the dynamics of dwarf mistletoe in the understory trees in the subplot area. A total of 265 western larch overstory trees were sampled on the subplots and surrounding buffers; 255 of these trees were visibly infected. There were an average of 37 infected larch overstory trees per acre in the entire study area prior to treatment. The percent of larch overstory trees infected with dwarf mistletoe on the subplots plus buffers ranged from 77 to 100 percent with a mean of 96 percent (sd=6). $\overline{DMR}$ for overstory larch trees on the subplots plus buffers ranged from 2.28 to 5.76 with a mean of 4.78 (sd=.80), and $\overline{DMI}$ ranged from 2.93 to 5.76 with a mean of 4.92 (.66). These figures show that there was a very high incidence of dwarf mistletoe in the larch overstory trees and that the severity of infection was also quite high. A total of 123 tagged overstory trees remained in the study following all treatments and should provide an excellent opportunity for tracking dwarf mistletoe-related mortality in these mature trees over time.

Multiple regression analysis using SYSTAT was used to examine the relationship between the infected overstory trees and the percent of infected larch understory trees on each subplot. The arcsine of the square root transformation of the percent infected larch (ARCINF) was used as the dependent variable. The independent variables used in the analysis were the number of infected larch overstory trees per subplot and buffer (OSINF), DMR of the larch overstory trees (OSDMR), $\overline{DMI}$ of the larch overstory trees (OSDMI), average height of the larch overstory trees (OSHGT), arcsine of the square root transformation of the percent infected larch overstory trees (AROSIN), and the interaction variable of OSDMI X OSHT (DMIHGT). The results of the multiple regression analysis show that the variables of OSDMI, OSHGT, and DMIHGT were the best predictors and the variation of infection in the larch understory trees in relationship to the overstory characteristics could be best explained by the following equation:

$$ARCINF = -0.146209 + 0.030479(OSDMI) + 0.000687(OSHGT) + 0.000007(DMIHGT).$$

$$R^2 = .722$$

Table 5.--Number of trees, average height (HGHT), average diameter at breast height (DBH), basal area (BA), and age of overstory trees for each subplot, grouped by treatment.

	No. of trees	HGHT (ft)	DBH (in)	BA (ft^2/ac)	Age
Logged, Thinned*					
I 1a	6	64.2	10.6	15.20	196
II 1a	6	107.8	22.1	64.12	182
III 1a	11	86.1	14.9	57.72	196
IV 1a	15	104.6	17.3	35.49	194
$\bar{x}$	10	90.7	6.2	43.13	192
Logged, Unthinned*					
I 1b	16	65.8	10.6	43.70	195
II 1b	1	127.0	24.3	12.88	191
III 1b	4	82.0	15.0	21.64	191
IV 1b	5	104.0	19.4	43.64	191
$\bar{x}$	7	94.7	17.3	30.47	192
Unlogged, Thinned					
I 2a	9	80.8	15.4	51.66	196
II 2a	9	84.3	15.6	53.36	165
III 2a	7	83.1	14.7	37.20	158
IV 2a	18	74.8	14.1	83.99	197
$\bar{x}$	11	80.8	15.0	56.55	179
Unlogged, Unthinned					
I 2b	3	69.7	15.3	16.38	152
II 2b	6	83.5	16.2	35.17	172
III 2b	9	86.9	18.5	68.82	176
IV 2b	11	81.9	13.6	45.37	161
$\bar{x}$	7	80.5	15.9	41.44	165

* Data was taken prior to logging treatment

Table 6.--Number of trees, number infected, percent infected, average dwarf mistletoe rating ($\overline{DMR}$), average dwarf mistletoe rating of infected trees ($\overline{DMI}$), and average height of infected trees (HGHT) for western larch overstory trees for each subplot and its surrounding buffer zone, grouped by treatment.

	# Larch Overstory trees	# Infected	% Infected	$\overline{DMR}$	$\overline{DMI}$	HGHT infected Trees (ft)
Logged, Thinned*						
I 1a	11	11	100	5.73	5.73	70.4
II 1a	11	11	100	5.00	5.00	113.0
III 1a	22	22	100	5.27	5.27	91.1
IV 1a	12	12	100	5.33	5.33	111.8
$\bar{x}$	14	14	100	5.33	5.33	96.6
Logged, Unthinned*						
I 1b	25	25	100	5.76	5.76	75.3
II 1b	12	12	100	5.08	5.08	111.4
III 1b	15	15	100	4.67	4.67	98.3
IV 1b	15	15	100	4.87	4.87	113.8
$\bar{x}$	17	17	100	5.10	5.10	99.7
Unlogged, Thinned						
I 2a	20	19	95	4.40	4.63	99.7
II 2a	20	19	95	4.85	5.11	94.9
III 2a	12	12	100	5.08	5.08	80.1
IV 2a	16	15	94	3.75	4.00	87.8
$\bar{x}$	17	16	96	4.52	4.71	90.6
Unlogged, Unthinned						
I 2b	16	15	94	4.75	5.06	89.3
II 2b	18	14	77	2.28	2.93	85.4
III 2b	18	16	88	4.78	5.38	84.7
IV 2b	22	22	100	4.82	4.82	86.7
$\bar{x}$	19	17	90	4.16	4.55	86.5

* Data was taken prior to logging treatment

SUMMARY

The incidence of dwarf mistletoe infection in the understory trees was high throughout the study area even though these trees were less than 20 years old. The high level of infection in the understory trees was greatly influenced by the severity level of dwarf mistletoe infection in the overstory trees. The severity of infection in individual understory trees was low and the dwarf mistletoe was not yet causing any growth effects in these trees. Statistical analysis showed that there were no significant differences between treatment groups for variables used to measure dwarf mistletoe spread and intensification and disease effects on tree growth to account for in the future analyses of treatment effects.

REFERENCES CITED

Hawksworth, F.G. 1977. The 6-class dwarf mistletoe rating system. USDA For. Serv. Gen. Tech. Rept. RM-48. Rocky Mountain Forest and Range Experiment Station. 7 p.

Hawksworth, F.G., D.W. Johnson. 1989. Biology and management of dwarf mistletoe in lodgepole pine in the rocky mountains. UDSA For. Serv. Gen. Tech. Rept. RM-169. Rocky Mountain Forest and Range Experiment Station. 38 p.

Hawksworth, F.G., D. Wiens. 1972. Biology and classification of dwarf mistletoes (*Arceuthobium*). USDA For. Serv. Agriculture Handbook No. 401. 243 p.

Hawksworth, F.G., J.C. Williams-Cipriani, B.B. Eav, B.W. Geils, R.R. Johnson, M.A. Marsden, J.S. Beatty, G.D. Shubert. 1992. Interim dwarf mistletoe impact modeling system. User's quide and reference manual. USDA For. Serv. Rep. MAG-91-3. Methods Application Group. Ft. Collins, Co. 89 p.

Pfister, R.D., B.L. Kovalichik, S.F. Arno, R.C. Presby. 1983. Forest habitat types of western Montana. USDA For. Serv. Gen. Tech. Rept. INT-34. Intermountain Forest and Range Experiment Station. 174 p.

Schefler, W.C. 1980. Statistics for the Biological Sciences. Addison-Wesley Publishing Company, Inc. Reading, Massachusetts. 230 p.

Stage, A.R. 1973. Prognosis model for stand development. USDA For. Ser. Res. Pap. INT-164. Intermountain Forest and Range Experiment Station. 32 p.

UDSA Forest Service. 1989. Stand examination field instructions: Region one. Timber management data handbook. FSH 2409.21h. R1. Chapter 400. USDA For. Serv., Northern Region. Missoula, MT.

Wilkinson, L. 1989. SYSTAT: The System for Statistics. SYSTAT, Inc. Evanston, IL. 822 p.

Wykoff, W.R.,N.L. Crookston, and A.R. Stage. 1982. User's guide to the stand prognosis model. USDA Gen. Tech. Rept. INT-133. Intermountain Forest and Range Experiment Station. 112 p.